

TRANSMISSION CONFIGURATION, IN PARTICULAR FOR MOBILE RADIO
COMMUNICATION, AND MOBILE STATION WITH THE TRANSMISSION
5 CONFIGURATION

Cross-Reference to Related Application:

This application is a continuation of copending International
Application No. PCT/DE02/01673, filed May 8, 2002, which
10 designated the United States and which was not published in
English.

Background of the Invention:

Field of the Invention:

15 The present invention relates to a transmission configuration,
in particular for mobile radio, and to the implementation of
such a transmission configuration in a transmission method.

In mobile radio, a distinction is normally drawn between
20 mobile stations and fixed stations, with two or more mobile
stations being able to communicate with one fixed or base
station at the same time.

A carrier frequency is modulated with data to be transmitted,
25 such as speech data or text data, by means of modulators in
transmission devices for mobile stations, in accordance with

standardized modulation methods, such as GSM (Global System for Mobile Communication), EDGE, TIA-EIA136, UTRA FDD (UMTS, Universal Mobile Telecommunication Standard), UTRA TDD, IS-95 etc. Normally, modulators such as these have two or more
5 functional units, for example a baseband part and a radio-frequency part. The baseband part is used to produce a signal, which is normally a complex value and complies with a standard, by means of digital signal processing from the data to be transmitted. This complex-value signal is shifted in the
10 radio-frequency part to a radio-frequency level, for example using a homodyne or heterodyne transmission architecture, and is transmitted as a real-value signal via a radio channel, for example by means of an antenna, after suitable power amplification.

15

Since the baseband part and radio-frequency part are subject to different physical requirements, these functional units are generally in the form of integrated circuits (chips), which are separate from one another and are produced by way of
20 different production processes. In this case, a suitable interface must be provided between the baseband component and the radio-frequency component and, at the current state of the art, is normally in the form of an analog signal interface. The baseband signals are thereby normally produced as complex
25 baseband signals at this interface, are broken down into a real part and an imaginary part, as the so-called IQ signal

with an in-phase component and a quadrature component that is phase-shifted through 90° with respect to the in-phase component. The I and Q components are in this case each generally transmitted as a difference signal, so that once again two lines need to be provided in each case. In addition to the large number of interface lines required as a consequence of this and, accordingly, a large number of pins for the integrated circuits involved, this known signal transmission requires high-quality analog signal processing components, such as digital/analog converters and amplifiers, both on the radio-frequency side and on the baseband side.

Furthermore, special signal processing steps relating to the radio-frequency part normally have to be carried out in the baseband circuit part, in order to compensate for and to correct in advance for incompatibilities, non-ideal features or tolerances in the radio-frequency part. In consequence, it is no longer possible to consider, analyze and develop the baseband part independently of the radio-frequency part. The continuous development in the field of digital signal processing and of modular concepts has resulted in an increase in the proportion of processing in baseband in comparison to the overall signal processing path to an ever greater extent, in particular with regard to the interaction with the radio-frequency part. This has undesirably resulted in restricted flexibility of baseband modules or baseband chips, since the

baseband modules can now be used only together with that radio-frequency assembly which has been developed especially for it.

5 Summary of the Invention:

It is accordingly an object of the invention to provide a transmission configuration, in particular for mobile radio, as well as an implementation of the transmission configuration, which overcomes the above-mentioned disadvantages of the heretofore-known devices and methods of this general type and which makes it possible to achieve a high degree of flexibility, that is to say which allows baseband processing independently of the radio-frequency part, while having a low degree of complexity, in particular a small number of pins.

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With the foregoing and other objects in view there is provided, in accordance with the invention, a transmission configuration, in particular for mobile radio transmission, comprising:

20 a baseband component for processing a baseband signal, the baseband component having an input/output configured for digital data transmission;

a radio-frequency component for conversion of the baseband signal to a radio-frequency signal to be transmitted, the

radio-frequency component having an input/output for digital data transmission and being connected, via an interface, to the input/output of the baseband component for digital transmission of payload data to be transmitted and of configuration data for configuration of the radio-frequency component;

a first digital multiple conductor connection for transmitting the payload data connected between the input/output of the baseband component and the input/output of the radio-frequency component; and

a second digital multiple conductor connection for transmitting the configuration data connected between the input/output of the baseband component and the input/output of the radio-frequency component.

In a first embodiment of the invention, the first digital multiple conductor connection includes:

a data line for serial data transmission of payload data;

a bit clock line for transmission of a clock signal, with

in each case one bit of the data line being associated with in each case one clock period; and

a word clock line for indicating a start of transmission of a sequence of bits on the data line.

In a second embodiment of the invention, the second digital
5 multiple conductor connection includes:

a data line for serial data transmission of the configuration data;

a bit clock line for transmitting a clock signal with one clock period each associated with one bit each on the
10 data line; and

a selection line for activating the radio-frequency component.

In this context, payload data to be transmitted means that
15 data which is modulated onto a carrier frequency in the radio-frequency part and, for example, is transmitted by an antenna. The data may also be referred to as useful data.

The expression configuration data means that data with which
20 the radio-frequency component can be configured for example the type of modulation in the transmitter, the amplitude, the transmission power profile, the transmission frequency, the transmission time, the transmission duration, the transmission

mode, the switching-on and off behavior of the transmitter, the so-called power ramping, and so on.

The described digital interface between the baseband component
5 and the radio-frequency component advantageously offers
baseband processing independently of the radio-frequency part.
No analog circuit components are required in the transmission
signal path in the baseband component, so that a high degree
of integration density and, in particular, a high degree of
10 independence of manufacturing scatters can be ensured. There
is no need whatsoever for an analog interface between the
baseband part and the radio-frequency part. Both modulation
data (payload data) and configuration data can be transmitted
from the baseband part to the radio-frequency part via the
15 described digital interface. Furthermore, the described
digital interface requires only a small number of lines, as
well as low data rates.

Signal processing steps can be carried out at the information
20 bit level in the baseband component, for example the formation
of transport blocks, error protection coding, adaptation of
the bit rate, channel coding such as convolutional and/or
turbo coding, interleaving, transport stream multiplexing,
frame and packet segmentation and so on. Those signal
25 processing steps at the physical level which correspond to
layer 1 of the OSI layer model, such as pulse shaping,

modulation, advance correction and compensation, can be carried out by means of the described digital interface completely in the radio-frequency component, and accordingly independently of the baseband.

5

Overall, the described transmission configuration is particularly suitable for use in mobile radio stations, to support the GSM, EDGE TIA/EIA136 mobile radio standards, as well as to support third-generation mobile radio standards
10 such as, for example, UTRA FDD, UTRA TDD or IS-95.

The exclusively digital interface allows a considerably simpler circuit layout and circuit design in the baseband module and radio-frequency module. Furthermore, a considerably
15 higher degree of flexibility is obtained as a result of the fact that those digital signal processing steps that are required for compensation and/or for advance correction of the radio-frequency signals can be carried out directly in the radio-frequency assembly, that is to say in the radio-
20 frequency component, so that, depending on the application, one baseband module can be coupled to different radio-frequency modules.

The exclusively digital form of the baseband module allows the
25 use of low-cost production processes with little complexity, since no analog circuit components need be integrated.

Furthermore, this allows matching to future manufacturing processes with high integration densities, with a very low level of complexity.

- 5 The baseband component and the radio-frequency component may be integrated circuits (chips) that are separate from one another.

As noted above, a first multiple conductor connection is
10 provided for transmission of the payload data, is connected at one end to the input/output of the baseband component and is connected at the other end to the input/output of the radio-frequency component, and in which a second multiple conductor connection is provided for transmission of the configuration
15 data, is connected at one end to the input/output of the baseband component, and is connected at the other end to the input/output of the radio-frequency component.

The separate data transmission of payload data and
20 configuration data via the first and second multiple conductor connections simplifies and separates the configuration of the signal processing in the baseband module since, normally, the payload information and the configuration information are normally respectively provided separately from a digital
25 signal processor in the baseband module and from a microcontroller in the baseband module, and are also

transmitted independently of one another via the digital interface when using the present configuration.

As has already been described, the payload data mainly
5 comprises the modulation data for the radio-frequency module for modulation of a carrier frequency, while the configuration data comprises the information for configuration of the radio-frequency component itself, for example the transmission frequency, the transmission amplitude, the transmission power
10 and other transmission parameters.

The separate digital transmission of payload data and configuration data is advantageously carried out by means of message-oriented or packet-oriented transmission protocols.

15

Separate inputs/outputs, which are provided independently of one another, can respectively be formed in the baseband component and in the radio-frequency component for the first and second multiple conductor connections.

20

By way of example, the baseband module may have a first input/output which is coupled to the digital signal processors for transmission of the payload data, while a second input/output can be provided on the baseband component for
25 transmission of the configuration data, and is coupled to the microcontroller in the baseband component.

The radio-frequency component preferably comprises a modulator, a digital/analog converter as well as a frequency converter for conversion of a signal from baseband to a radio-
5 frequency signal. Furthermore, a power amplifier may be provided, whose output is coupled to an antenna.

As noted above, the first digital multiple conductor connection, in the first aspect of the invention, comprises a
10 data line designed for serial data transmission, a bit clock line designed for transmission of a clock signal, with in each case one bit of the data line being associated with in each case one clock period, and a word clock line designed for indication of the start of transmission of a sequence of bits
15 on the data line.

The data to be transmitted via the data line can be organized in transmission units, so-called messages, which each comprise, for example, 16 bits arranged in serial form. A
20 transmission pulse (Burst) from the transmission circuit may once again comprise, for example, a sequence with a total of 11 messages, each having a length of 16 bits, for GSM.

Owing to the relatively small amounts of data to be
25 transmitted, serial digital transmission methods can advantageously be used, in particular with standardized

transmission protocols or modified transmission protocols such as I²S or I²C.

In a further preferred embodiment to the present invention,
5 the second digital multiple conductor connection comprises a data line designed for serial data transmission of the configuration data, a bit clock line for transmission of a clock signal, with in each case one clock period being associated with in each case one bit to be transmitted on the
10 data line, and a selection line for activation of the radio-frequency component, or of a circuit element in the radio-frequency component.

The configuration data may also be transmitted via a second
15 digital multiple conductor connection, which is in the form of a three-conductor interface, with the transmission protocol preferably being organized in messages. These may be individual messages or a group of messages which follow one another immediately. Since, with regard to the present subject
20 matter, the payload data can be transmitted completely independently of the configuration data, this means that it is possible, for example, for a microcontroller in the baseband module to transmit transmission parameters to the radio-frequency assembly at times which it determines itself,
25 without this having any influence on the digital signal processor in the baseband module, and without there even being

any need for any interrupt in the payload data transmission or processing. This considerably simplifies the timing, and its coordination, in the baseband component.

5 Configuration data determines, for example, the type of modulation, such as GMSK or QAM, the amplitude, the transmission power profile, the transmission frequency, the transmission time, the transmission duration, the transmission mode, the switching-on and off behavior of the transmitter,
10 etc.

In a further preferred embodiment to the present invention, a synchronization line is provided for synchronization of the payload data in the radio-frequency component, is connected at
15 one end to the input/output of the baseband component, and is connected at the other end to the input/output of the radio-frequency component.

The synchronization line allows synchronization data to be
20 transmitted defining the time of the respective start and end of transmission on the output side of the radio-frequency component, that is to say at the radio-frequency carrier level, for example when transmitting in time slots, so-called bursts.

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In a further preferred embodiment of the present invention, the inputs/outputs of the baseband and radio-frequency components are designed for serial data transmission. Serial data transmission, in the present case serial digital data
5 transmission, advantageously allows the use of digital transmission methods with standardized transmission protocols, such as I²S or I²C on the basis of the small amounts of data to be transmitted in this case.

10 In a further preferred embodiment of the present invention, the inputs/outputs of the base band component and radio-frequency component are designed for unidirectional data transmission from the baseband component to the radio-frequency component, but not in the opposite direction. This makes it possible to
15 achieve a considerable reduction in the complexity for implementation of the described digital interface.

In a further preferred embodiment of the present invention, a digital interrupt request line is connected between the
20 baseband component and the radio-frequency component, for initiating resumption of the data transmission of the baseband component through the radio-frequency component.

In a further preferred embodiment of the present invention, an
25 additional control line for driving a power amplifier for amplification of the radio-frequency signal is provided

between the baseband component and the radio-frequency component. The power amplifier may, for example, be provided on the output side in the radio-frequency component and may, for example, provide a coupling to an antenna from a frequency
5 converter which converts baseband to radio-frequency. In order to drive the power amplifier, in particular its switching-on and off behavior, or power ramping, it may be preferable to use an analog drive rather than a digital drive for the power amplifier, depending on the application, which involves a low
10 degree of circuitry complexity.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

15 Although the invention is illustrated and described herein as embodied in a transmission configuration, in particular for mobile radio, as well as use of a transmission configuration, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may
20 be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention,
25 however, together with additional objects and advantages thereof will be best understood from the following description

of specific embodiments when read in connection with the accompanying drawings.

Brief Description of the Drawings:

5 Fig. 1 is a simplified block diagram showing a first exemplary embodiment of the present invention;

Fig. 2 is a timing line shows examples of signal waveforms on the three-conductor connection for transmission of the payload
10 data via the interface shown in Fig. 1;

Fig. 3 illustrates examples of signal waveforms for the configuration data for transmission via the interface shown in Fig. 1; and

15

Fig. 4 is a graph of the signal waveforms to show the relationship between the transmission of configuration data, payload data and synchronization data, as well as the fundamental waveform of the transmission power via the
20 interface as shown in Fig. 1.

Description of the Preferred Embodiments:

Referring now to the figures of the drawing in detail and first, particularly, to Fig. 1 thereof, there is shown a
25 transmission circuit with a baseband component 1 and radio-frequency component 3 which is connected to it via an

interface 2. The baseband component 1 is used for digital processing of useful data, referred to as payload data herein, to be transmitted. The baseband component 1 comprises a digital signal processor 11 for processing the payload data, as well as a microcontroller 12 for controlling the radio-frequency component by means of the configuration data, as well as for overall sequence control.

The radio-frequency component 3 in the present exemplary embodiment comprises a power amplifier 31 which, in alternative embodiments, may also be in the form of an external component, separately from the radio-frequency module 3. The output side of the power amplifier 31 is connected to an antenna via an antenna line 32 which is designed for transmission of radio-frequency modulated signals.

The interface 2 between the baseband component 1 and the radio-frequency component 3 comprises a first multiple conductor connection 21, designed for transmission of the payload data which is provided from the digital signal processor 11, a second digital multiple connection 22, designed for transmission of configuration data for controlling the radio-frequency component 3 and coupled to the microcontroller 12 in the baseband component 1, a synchronization line 23 for definition of the start and end of the transmission time slots in the transmission signal 32, as

well as an interrupt request line 24, by means of which the radio-frequency module 3 causes the baseband module 1 to carry out a new action, in particular to transmit data once again.

5 While the two multiple conductor connections 21, 22 as well as the synchronization line 22 are in the form of unidirectional data lines in the present exemplary embodiment, that is to say they are designed to transmit only in the direction from the baseband component 1 to the radio-frequency component 3, the
10 interrupt request line 24 is designed for transmission in an opposite signal direction from the radio-frequency component 3 to the baseband component 1.

Since the interface 2 is an exclusively digital interface, the
15 base module 1 can advantageously be designed completely using digital circuitry. Furthermore, the complete separation of the respective digital payload data transmission from the configuration data transmission allows the baseband component 1 configuration to be considerably simplified, since there is
20 no coupling of data provided from the digital signal processor 11 and data provided from the microcontroller 12. Furthermore, there is no need for the hybrids (that is to say partially analog and partially digital circuitry) which were previously normally used in baseband modules.

In addition, the interface 2 has only 8 lines, namely in each case three lines for the digital multiple conductor connections and in each case one line for the synchronization and interrupt request, thus allowing the chips that are involved to have a
5 small number of pins.

By way of example, Fig. 2 shows signal waveforms on the three lines comprising the word line WA0, the bit clock line CL0 and the data line TX which are formed from the first digital
10 multiple conductor connection 21. This first digital multiple conductor connection 21 is a modified unidirectional I²S interface which has in each case one line connection for the word clock, for the bit clock and for the data transmission, WA0, CL0, TX. The serial transmission of the data via the line
15 TX is in this case organized in the form of messages, with a message in the present example comprising 16 bits arranged in serial form. In this case, the most significant bit (MSB) is transmitted first of all, and the least significant bit (LSB) is transmitted last. In the present case, the most significant
20 bit is used to identify whether the fifteen less significant bits contain payload information, that is to say modulation bits for modulation of a carrier oscillation in the radio-frequency component, or control information, that is to say data for controlling the serial transmission or the nature of
25 the serial transmission and the transport format for the payload data, that is to say whether these are modulation bits

for Gaussian minimum shift keying, EDGE or other types of modulation. One modulation bit on the data line TX is in each case clocked into the radio-frequency component 3 on each falling clock edge of the periodic clock signal CL0, the so-called bit clock. The word clock signal WA0 defines the start of the transmission of a message by a falling clock edge in the bit clock occurring at the same time as a word clock pulse. The data transmission then starts on the next falling clock edge of the bit clock.

10

Table 1 is shown below, and, by way of example, shows the transmission of 157 modulation bits of a complete GSM transmission pulse (burst) for GMSK modulation as a sequence of a total of 11 messages, each with a length of 16 bits. The MSB is zero, so that the transmitted bits are payload data, in this case modulation bits.

No.	Message																Content
1	0	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	0-14
2	0	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	15-29
3	0	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	30-44
4	0	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	45-59
5	0	74	73	72	71	70	69	68	67	66	65	64	63	62	61	60	60-74
6	0	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	75-89
7	0	104	103	102	101	100	99	98	97	96	95	94	93	92	91	90	90-104
8	0	119	118	117	116	115	114	113	112	111	110	109	108	107	106	105	105-119
9	0	134	133	132	131	130	129	128	127	126	125	124	123	122	121	120	120-134
10	0	149	148	147	146	145	144	143	142	141	140	139	138	137	136	135	135-149
11	0	0	0	0	0	0	0	0	0	156	155	154	153	152	151	150	150-156

Table 1

By way of example, Table 2 below, shows the transmission of control data for controlling the serial transmission via the payload data connection. The MSB is 1, and this therefore indicates that the message contains control information.

5

Message title	Bit number																Description
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
GMSK	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	This message is followed by 11 further messages with modulation bits for a GMSK transmission pulse as shown in Table 1
EDGE	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	This message is followed by 32 further messages with modulation bits for an EDGE transmission pulse
Empty buffer	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Previously transmitted data is invalid, empty the input buffer
IRQ empty	1	0	0	0	0	0	0	0	1	0	x	x	x	x	x	x	Initiate an interrupt request (IRQ) when there are only more xxxxxx ₈ unprocessed messages in the input buffer
IRQ full	1	0	0	0	0	0	0	0	1	1	x	x	x	x	x	x	Initiate an interrupt request (IRQ) when there is only more space for xxxxxx ₈ messages in the input buffer

Table 2

Fig. 3 shows the waveform of the signals via the total of three lines in the second digital multiple conductor connection 22 as shown in Fig. 1, based on an example. The second digital multiple conductor connection 22 is also designed for serial data transmission via the line data_out and additionally has a line for the bit clock clk_ser, as already described in Fig. 2, as well as a third line en_div for module selection, by means of which the module 3 which receives the configuration data or a circuit element of it, can be activated. The transmission protocol for the configuration data via the line 22 is also organized on a message basis, in which case the messages may either be individual messages or a group of messages which follow one another immediately. A message in this case comprises a defined total of $N+1$ bits, for example 24 bits, and is composed of an address part and a data part. The address part in this case comprises K bits and is identified by ADR, while the data part is identified by DTA and comprises $N-K+1$ bit. In the case of a message group transmitting data to successive addresses, the address part may be omitted if the initial address is known to the receiver. The receiver in this case is the radio-frequency module 3 which in this case receives configuration data, but transmits radio-frequency data via an antenna. The address then determines the destination, for example a function block to which the data should be transmitted in a radio-frequency module 3.

As is evident from Figs. 2 and 3 in conjunction with Fig. 1, the microcontroller 12 can transmit transmission parameters to the radio-frequency module 3, independently of payload data transmission, at times which it defines itself, without this influencing the digital signal processor 11 or the digital signal processor 11 even having to interrupt its processing or transmission of payload data, thus, overall, considerably simplifying the timing and sequence control in the baseband module 1.

Configuration data such as the type of modulation, the amplitude, the transmission power profile, the transmission frequency, the transmission time, the transmission duration, the transmitter mode, the switching on and off behavior of the transmitter, etc., are transmitted via the second multiple conductor connection 22.

A specific configuration message may be used for transmission of a message group, defining the start, the length and the start/destination address of the group, before the start of the message group. A message group is used, for example, to set the basic configuration for the transmitter efficiently with regard to time.

25

During the transmission of individual messages, the time of message transmission normally also determines the time at which the new setting becomes effective.

- 5 Data can also optionally be transmitted from the radio-frequency part to the baseband part by implementation of an additional connecting line, which is not illustrated in Fig. 3, with this data having previously been requested by means of a specific request message from the baseband part. This
- 10 request message may, for example, be characterized in that one bit in the address part is used to indicate that this is intended to be a read access rather than a write access to the address.
- 15 Finally, Fig. 4 shows the relationship between the transmission of payload data, configuration data and synchronization data, as well as the fundamental profile of the transmission power for a GSM-control transmission signal 32 as shown in Fig. 1. The payload data is in this case
- 20 transmitted via the first multiple conductor connection 21, the configuration data is transmitted via the second digital multiple conductor connection 22, and the synchronization data is transmitted via the synchronization line 23, as is shown in Fig. 1.

First of all, this ensures that all the configuration data that is required for transmission from the radio-frequency component via an antenna has been transmitted via the second digital multiple conductor connection 22 to the radio-

5 frequency assembly 3, and also that a sufficiently large number of modulation bits have been written via the first digital multiple conductor connection 21 to an input buffer for the radio-frequency assembly 3. A start signal can then be passed via the synchronization line 23 to the modulator in the
10 radio-frequency component 3, in order to start the modulation and transmission processes. For example, a rising edge identifies the transmission start, and a falling edge identifies an end of a transmission time slot (burst).

Overall, the times t1 to t8 denote the following significant
15 times for synchronization of the transmitter:

- t1 Start of transmission of configuration information,
- t2 Start of transmission of payload information,
- t3 End of transmission of configuration information,
- 20 t4 Start of the modulator,
- t5 Start of the upward power ramp,
- t6 End of the transmission of payload information,
- t7 Initiation of the transmission pulse,
- t8 End of the downward power ramp.

25